Toxic Cyanobacteria in Washington State

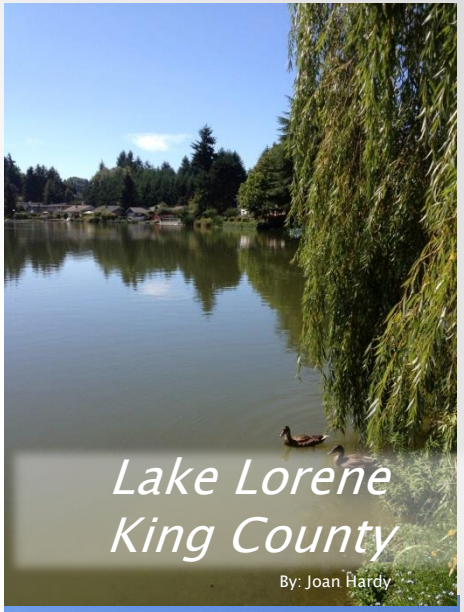
EPA Region 10
Harmful Algal Blooms Workshop
Seattle, Washington
March 2016

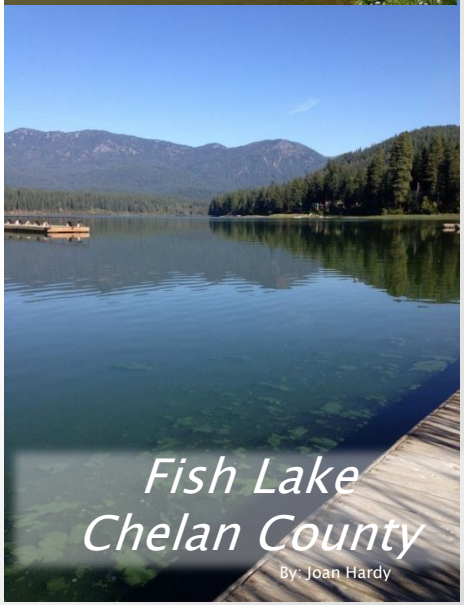
Washington State Department of Health

Public Health – Always Working for a Safer and Healthier Washington

Overview

- WA Freshwater Algae Control Program
- CyanoHABs
  - MCs
  - Anatoxin-a, others
  - Predictors of MCs in 9 Lakes
- Update on Other Studies
  - Fish Consumption
  - *Anabaena*
  - FW Microcystin transfer to Marine Waters
- 303d Narrative Criteria





Washington State Department of Health

Statewide Passive Surveillance Program

- Funded by $1/boat license fee
- Staff or citizens identify a bloom or developing bloom
- Check www.nwtoxicalgae.org
- Send sample to laboratory
- Results sent to LHJ, agencies, and posted on listserv

Washington State Department of Health

Washington State Toxic Algae

Freshwater algae bloom monitoring program

Home | Find lake | Report a bloom | Health risks | About toxic algae | Summaries | Program

Welcome to the freshwater algae site

The purpose of this site is to provide toxin data related to cyanobacteria blooms in Washington lakes, ponds and streams. Washington State Department of Ecology (Ecology) uses this site to share the data from their ongoing freshwater algae monitoring program.

Cyanobacteria (or blue-green algae) can produce toxins at levels that are harmful to humans, pets, domestic animals, and wildlife. There is no way to detect toxins in an algae bloom except through laboratory analysis. This website provides access to Ecology's results.

No lake is above guidelines

Find your lake

Use our database to locate a lake and find out the most recent testing.
Or find your lake >

Report a bloom

If you think that your lake has an algae bloom and you want to have the algae identified: Report a bloom.

See lakes with algae bloom

Examples of local lakes experiencing algae blooms. View our gallery and descriptions.

Health risks

Learn about the potential health risks to people and pets exposed to algae blooms through swimming or consuming the water.

News and announcements

8/12/2015 MyNorthwest.com
Green Lake: When in doubt, stay out

7/10/2015 Seattle Times
High temperatures, sunny skies could aggravate algal bloom in lakes

4/24/2015 Kirkland Reporter
Waverly Beach open; Kirkland waterfront parks remain posted with algae alerts

Washington State Department of Health | Department of Ecology State of Washington | King County

Report a Bloom: www.nwtoxicalgae.org

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How to report and test a bloom

Sampling a bloom event

If you have not participated in this program before and think that your lake is experiencing an algae bloom, please refer to the automated sample number generator below. The Dept of Ecology will approve testing of the sample after submittal. If the sample is not approved, we will contact you to let you know.

Directions can be found here about how to collect the sample and how to send or deliver it to the laboratory. It is very important for you to carefully follow the directions.

When collecting the sample, be sure to fill out the data sheet and send it along with your sample to the King County Environmental Lab.

To start the sampling process please use the automated sample number generator and follow the instructions.

Toxic algae caution sign at Lake Hicks

Marisa Burghdoff – Lake Ketchum

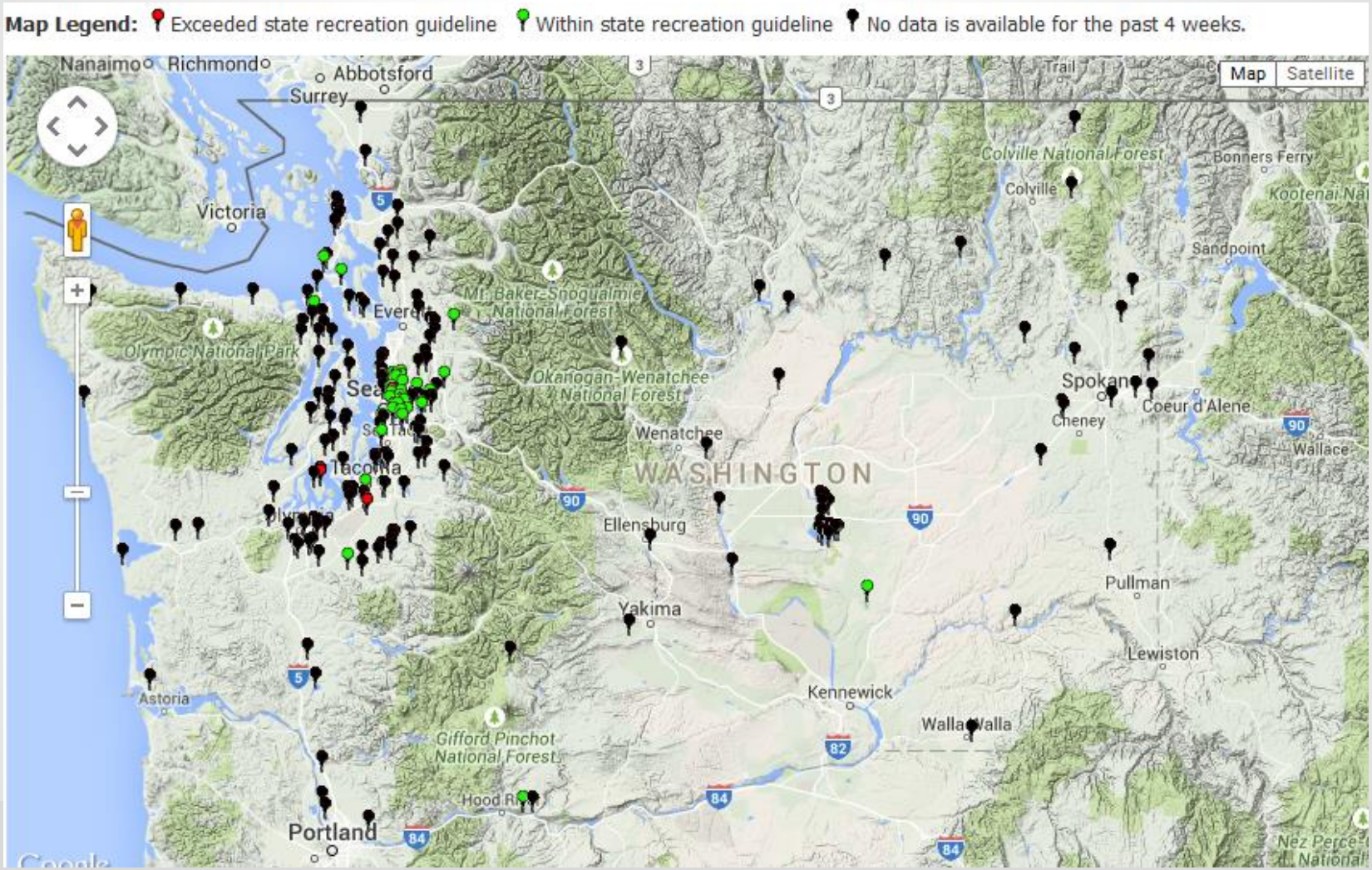
Once a sample is at the laboratory, specialists will identify the algae species. If the sample contains an algae known to produce toxins, the laboratory will run a toxin analysis on the sample and you may be asked to send in more samples. Be aware that Ecology cannot reimburse postage or delivery costs but does pay for laboratory analyses.

Resampling a bloom event

If you are submitting a follow-up sample for a lake that has already been tested in previous week (s), please follow the directions above. Please sample only one week after the toxin levels return below recreational levels. Samples will be approved by Ecology before testing.

Please work through Ecology. The laboratory will not accept outside samples through the Ecology program unless they have been approved by Ecology.

www.nwtoxicalgae.org –July 2015



The pins on the map represent the center of small lakes, regardless of where the sample was taken. To find more precise location information, download the toxin data and click the "view scum info" link. That is where specific sampling location information will be if it was provided. On larger lakes, (such as Lake Washington, Moses Lake and Potholes) pins represent the location of the sample if provided.

County
--All Counties--

WRIA
--All WRIAs--

Site
--All sites--

Toxin
--All toxins--

Minimum Toxin Concentration

Maximum Toxin Concentration

Start Date (MM/DD/YYYY)

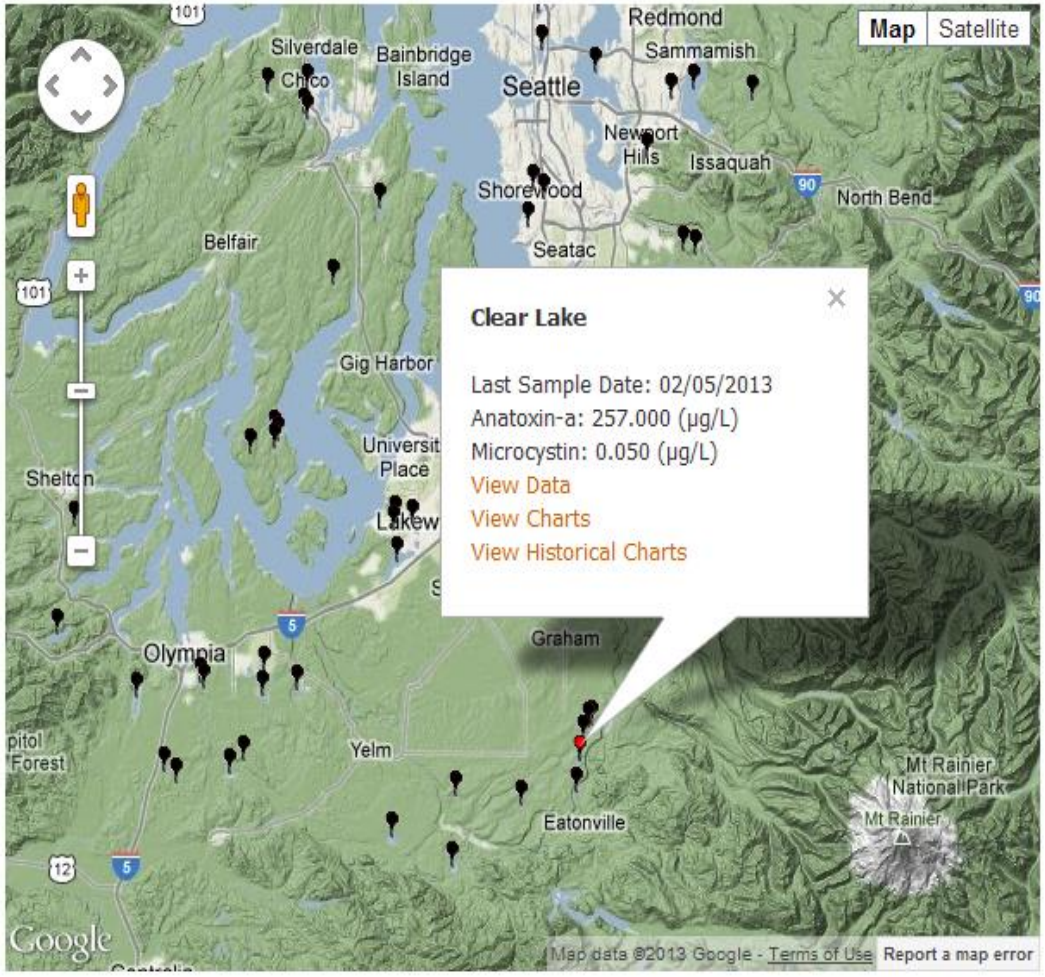
End Date (MM/DD/YYYY)

Lab Sample Number

Plot Map
Clear Selections

Hold **"shift" key** and drag a box around an area or **zoom in** using the slider on the left.

Map Legend: Exceeded state recreation guideline Within state recreation guideline
No data is available for the past 4 weeks.



Washington State Toxic Algae

Freshwater algae bloom monitoring program

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Detailed search for your lake

This database contains the most current toxicity data available. Since there is a lag time from the date of sample to the date of analysis, be sure to check the sample date when looking at data or before you use the lake. Remember to use caution and avoid scums. "When in doubt, stay out!"

Your local jurisdiction may have more specific information about your lake. Questions? Contact Lizbeth Seebacher at Department of Ecology.

If a lake is not listed, it has not been tested for toxic algae through the Ecology program.

The pins on the map represent the center of small lakes, regardless of where the sample was taken. To find more precise location information, download the toxin data and click the "view scum info" link. That is where specific sampling location information will be if it was provided. On larger lakes, (such as Lake Washington, Moses Lake and Potholes) pins represent the location of the sample if provided.

Toxin:

County	WRIA Number	Site	Lab Sample Number	Collect Date	Parameter	Toxin Conc. (µg/L)	MDL (µg/L)	Above State Guideline	Scum
Pierce	11	Clear Lake	L57212-1	01/03/2013	Anatoxin-a	125.000	0.019	Yes	No
Pierce	11	Clear Lake	L57212-1	01/03/2013	Microcystin	0.052	0.050	No	No
Pierce	11	Clear Lake	L57389-1	02/05/2013	Anatoxin-a	257.000	0.019	Yes	No
Pierce	11	Clear Lake	L57389-1	02/05/2013	Microcystin	<MDL	0.050	No	No
Pierce	11	Clear Lake	L57389-2	02/05/2013	Microcystin	<MDL	0.050	No	No
Pierce	11	Clear Lake	L57439-1	02/14/2013	Anatoxin-a	124.000	0.019	Yes	No
Pierce	11	Clear Lake	L57439-1	02/14/2013	Microcystin	<MDL	0.050	No	No

Plot Map

Clear Selections

Get data

Get Toxins

Get Phytoplankton

Export data

Export Toxin Data

Export Phyto Data

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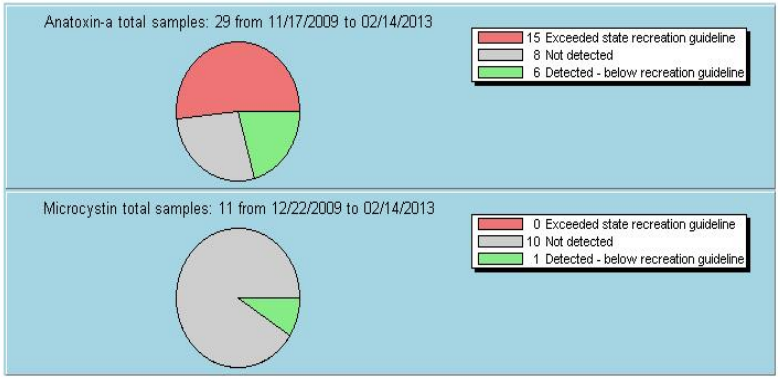
View Chart

Pick the lake you are interested in to view charts about each toxin tested for the history of the lake: Clear Lake, Pierce

Start Date (mm/dd/yyyy) End Date (mm/dd/yyyy) View Charts View Data



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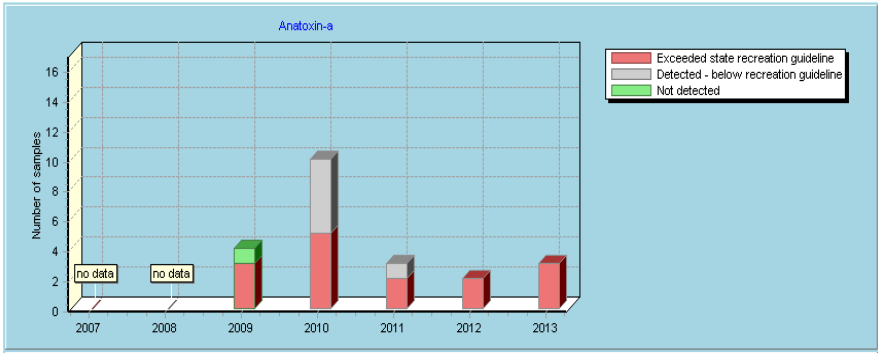
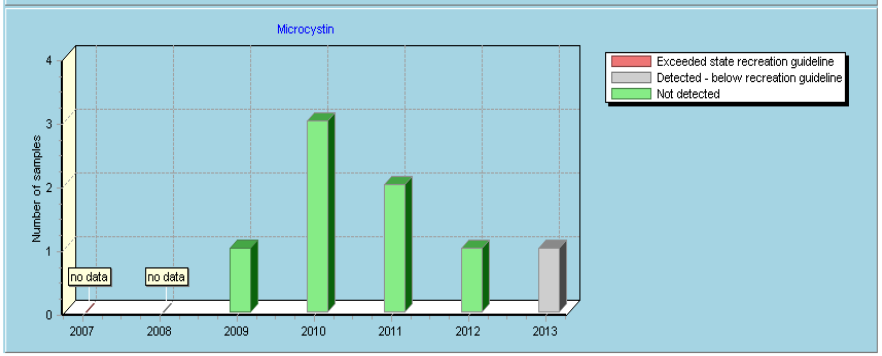
Historical summary of your lake

Pick the lake you are interested in to view charts about each toxin tested for the history of the lake: Clear Lake, Pierce

View Data

Note: Charts are based on number of samples taken for analysis of each toxin. Please pay attention to the y-axis when interpreting these charts.





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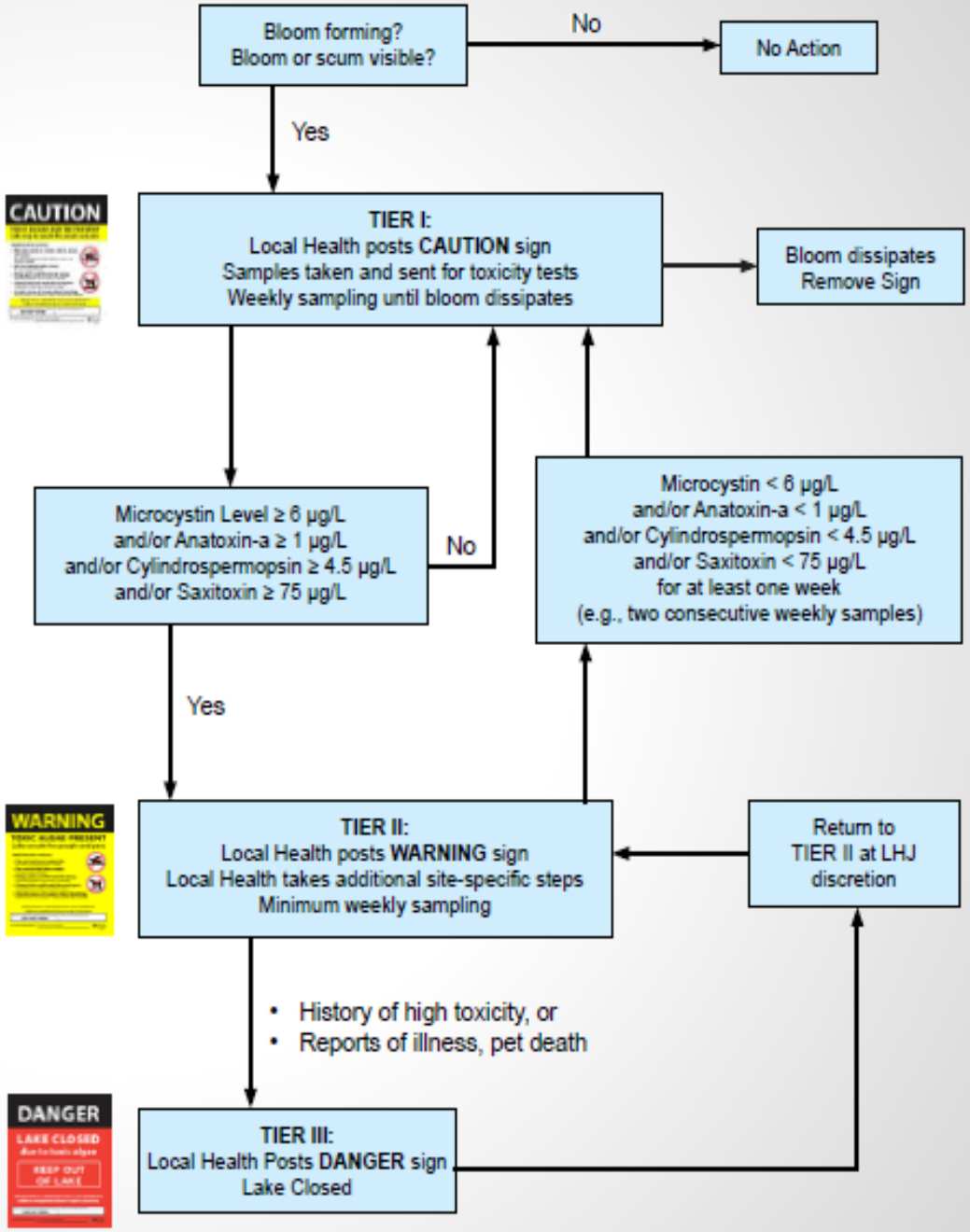
"Provisional" WA Recreational Guidance Values

HABs	Guidance Value (GV)
Microcystins	6 µg/L
Anatoxin-a	1 µg/L
Cylindrospermopsin	4.5 µg/L
Saxitoxins	75 µg/L

GVs will be updated when an acute RfD/TDI is available for each toxin or when a national guidance value is adopted

Washington State Department of Health

Lake Management Protocol



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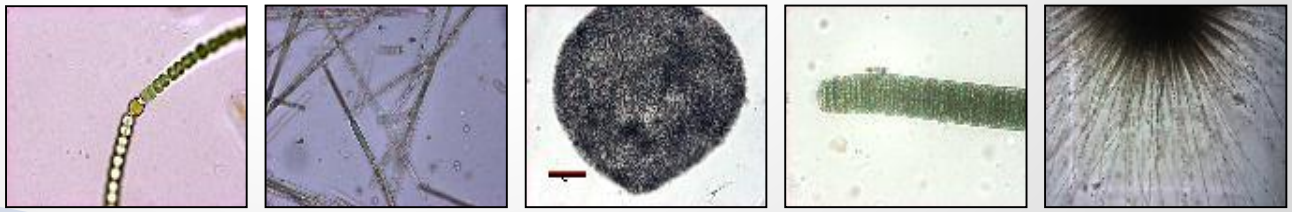
Most Common Toxic Genera in WA

- *Anabaena (Dolichospermum)* – anatoxin-a, microcystins, saxitoxins
- *Aphanizomenon* – anatoxin-a, saxitoxins, cylindrospermopsin
- *Microcystis* – microcystins
- *Oscillatoria* – microcystins, anatoxin-a, aplysiatoxins
- *Gloeotrichia* – microcystins



By: Robin Matthews

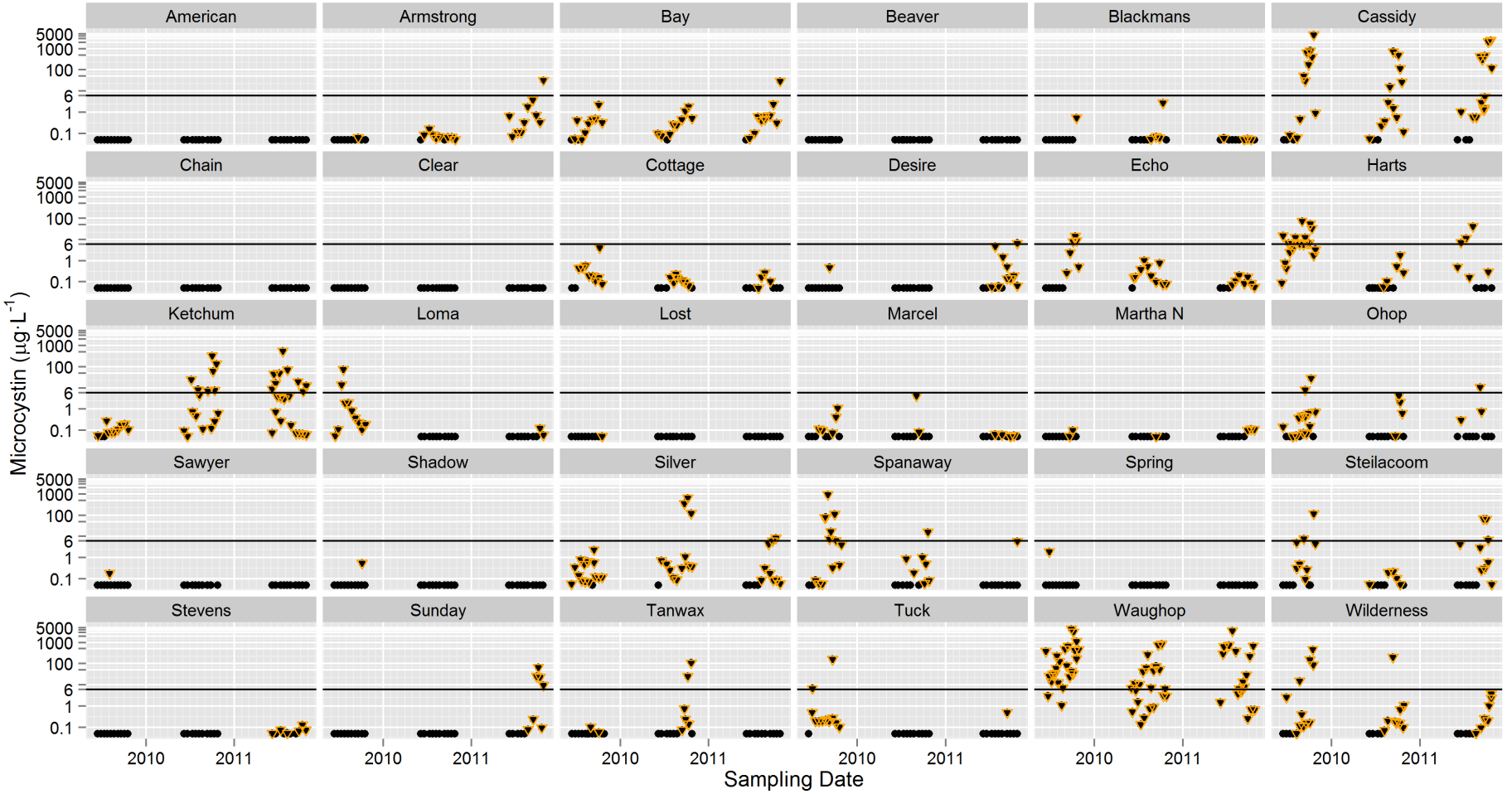
Washington State Department of Health

Cyanotoxins: FWACP and HABISS

- All Cyanotoxins:
  - MCs>Anatoxin-a>Saxitoxin or Cylindrospermopsins
- CDC HABISS Cooperative Agreement
  - Sampled 30 lakes for 3 years
  - Biweekly June – October
- Seasonal Results
- Monitoring Type
- Outreach Implications

Washington State Department of Health

MCs for 30 Lakes, Jun – Oct



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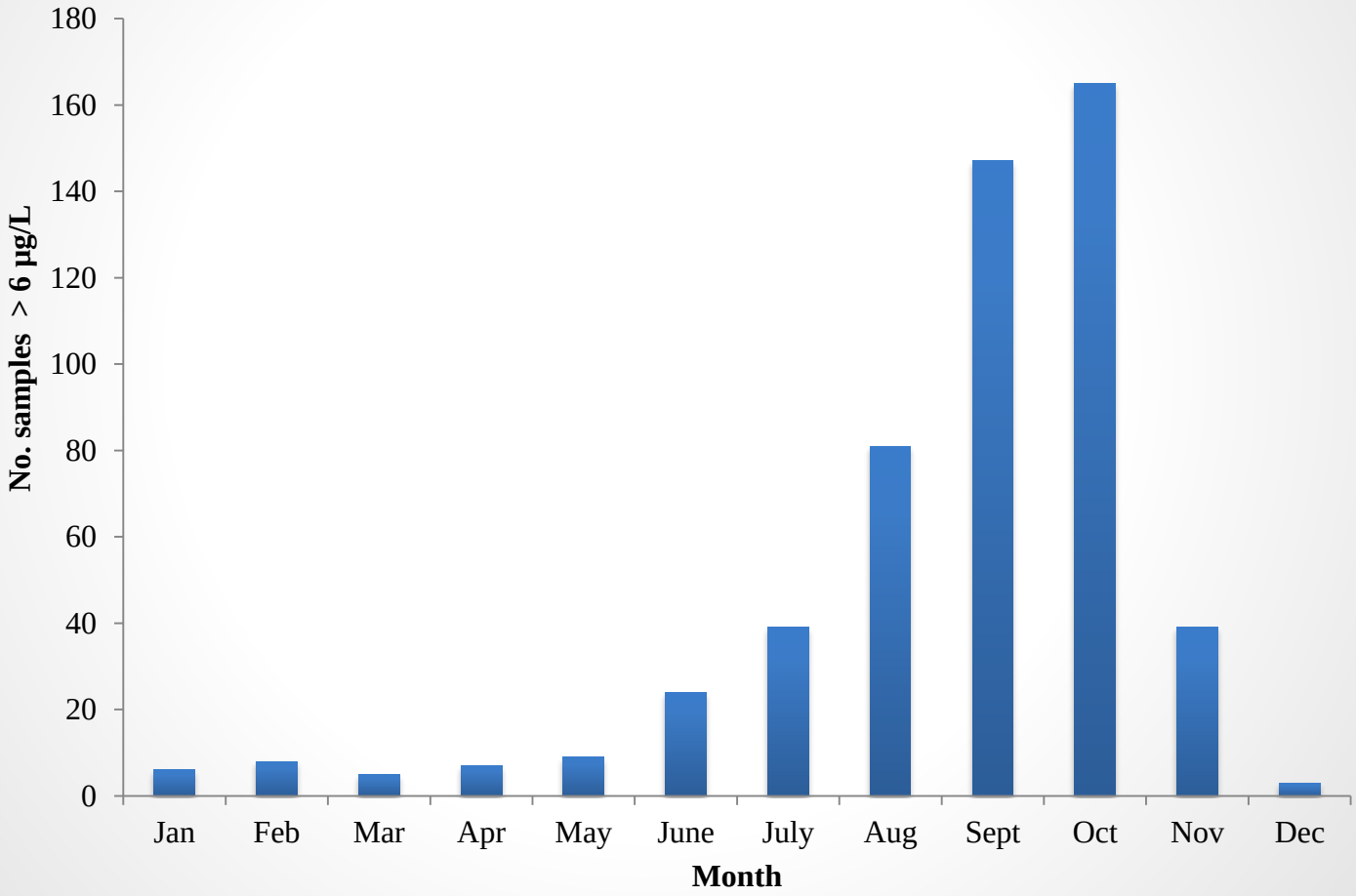
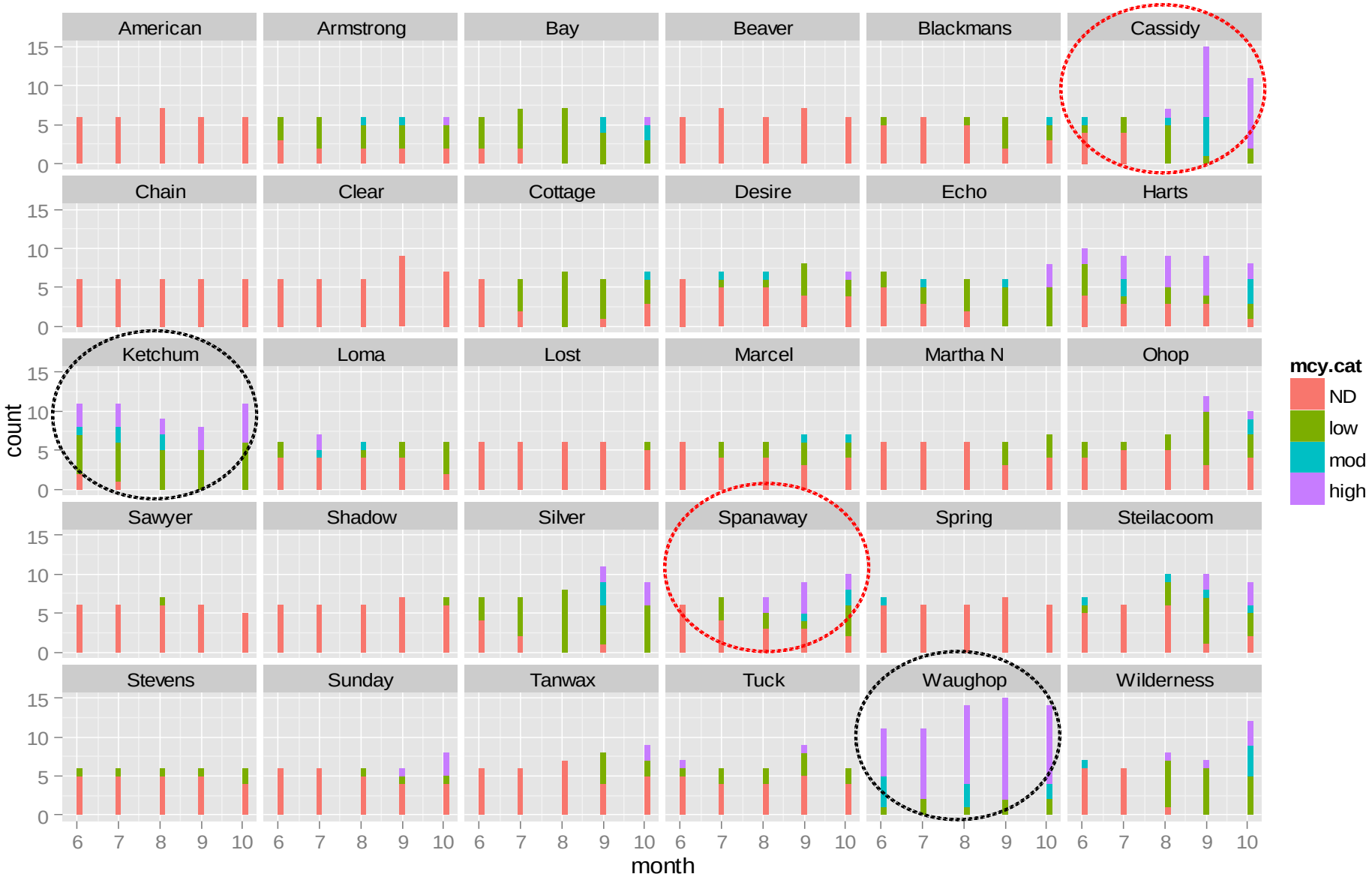
MC Samples > 6 µg/L by Month



Trainer, V. and FJ Hardy. 2015. Integrative Monitoring of Marine and Freshwater Harmful Algae in Washington State for Public Health Protection. Toxins 7, 1206-1234.

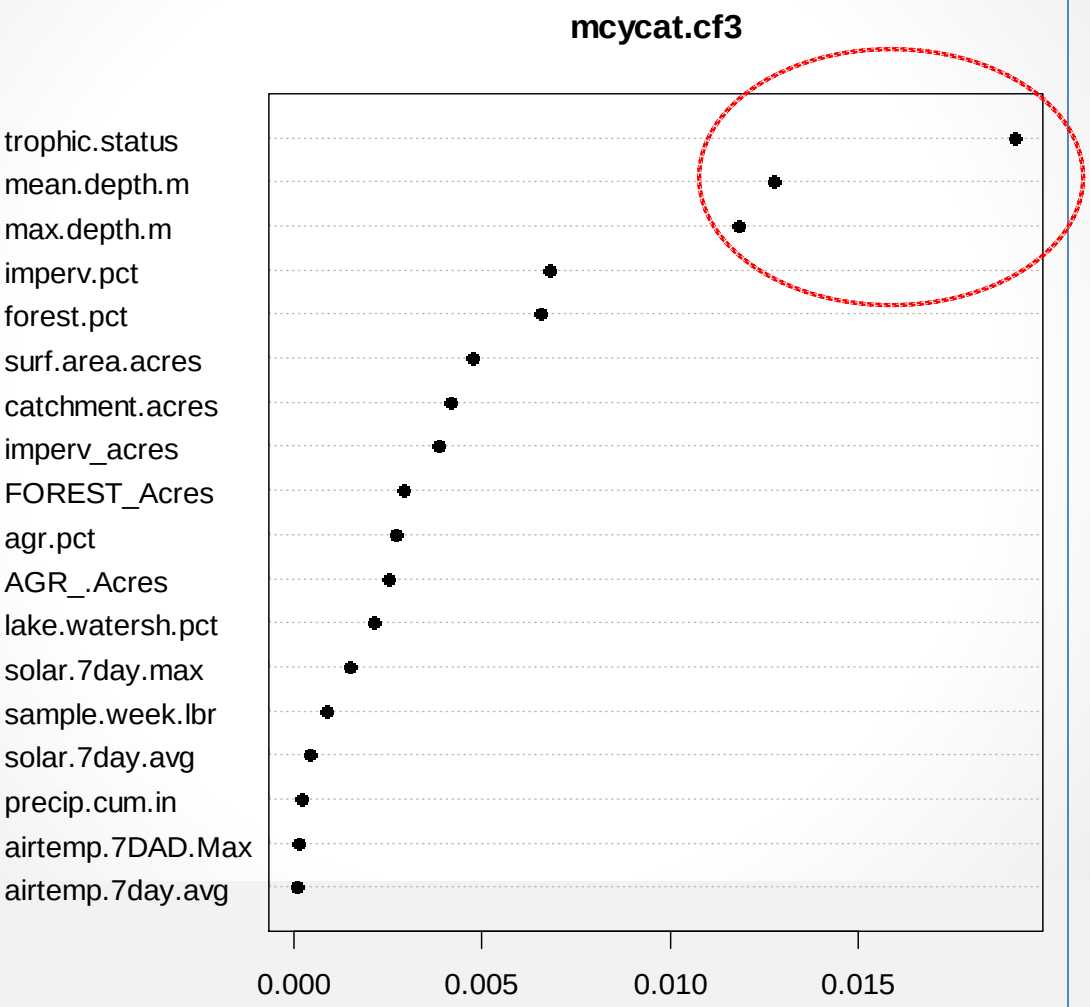
MCs by month for 30 Lakes



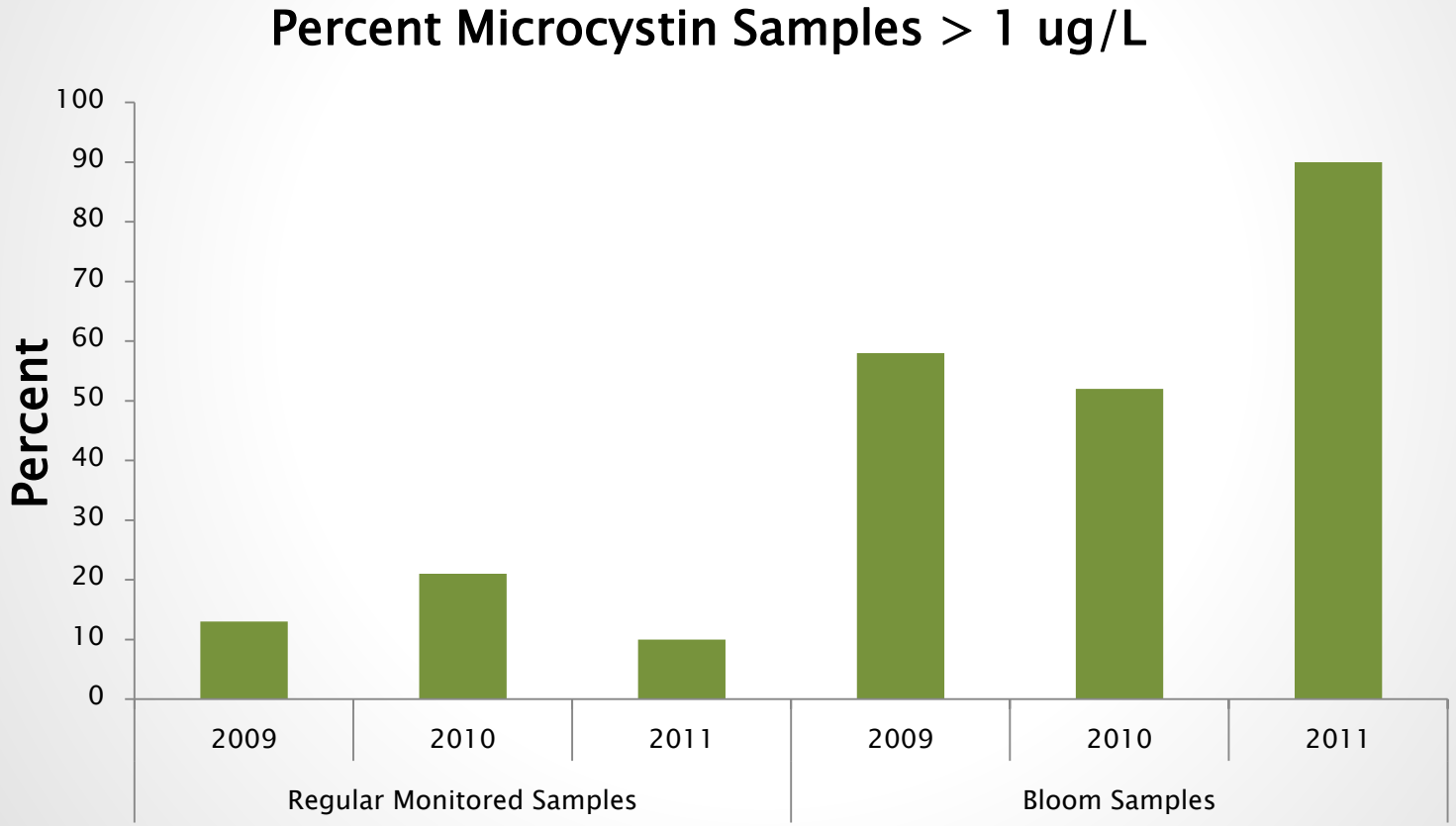
30 Lake Study – 6 Clusters

Group	Ag (%)	Forest (%)	Impervious Surfaces (%)	Lake Area (%)	Maximum Depth (m)	Comment	Lakes
1	0.8	79.2	3.7	4.7	10.9	Lowest development (impervious); most natural (forest). Small lakes relative to the size of the watersheds. moderate depths.	Armstrong, Ohop, Sawyer (#4 in R)
2	4.1	49.7	8.7	11.3	8.3	Low development; highest agricultural use, and high forest; intermediate sized lakes relative to the size of the watersheds. Shallow.	Bay, Cassidy, Desire, Harts, Spring, Tanwax (#2)
3	0.1	12.3	35.0	15.3	9.2	Most developed; low natural (forest) and least agriculture; intermediate lake:watershed values. shallow depths	Echo, Loma, Silver, Wilderness (#3)
4	0.9	8.7	11.3	5.8	14.0	Intermediate development (impervious surfaces); small lakes relative to size of watershed; moderate depths.	American, Ketchum, Lost, Spanaway (#5)
5	1.3	28.3	12.5	5.5	9.1	Intermediate development (impervious); small lakes relative to the size of the watersheds; shallow depths.	Beaver, Blackmans, Chain, Cottage, Marcel, Martha N, Shadow, Steilacoom, Sunday, Tuck, Waughop (#1)
6	0.8	17.4	13.0	29.5	36.6	Intermediate development; lake is a large percent of the watershed; deep lakes.	Clear and Stevens (#6)
Range	[0, 14]	[2, 86]	[1, 45]	[1, 38]	[3, 47]		

30 Lake Study – Predictive Model



MCY: Regular Monitoring vs Passive Surveillance



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Top 15 MC Concentrations 2008 – 2015

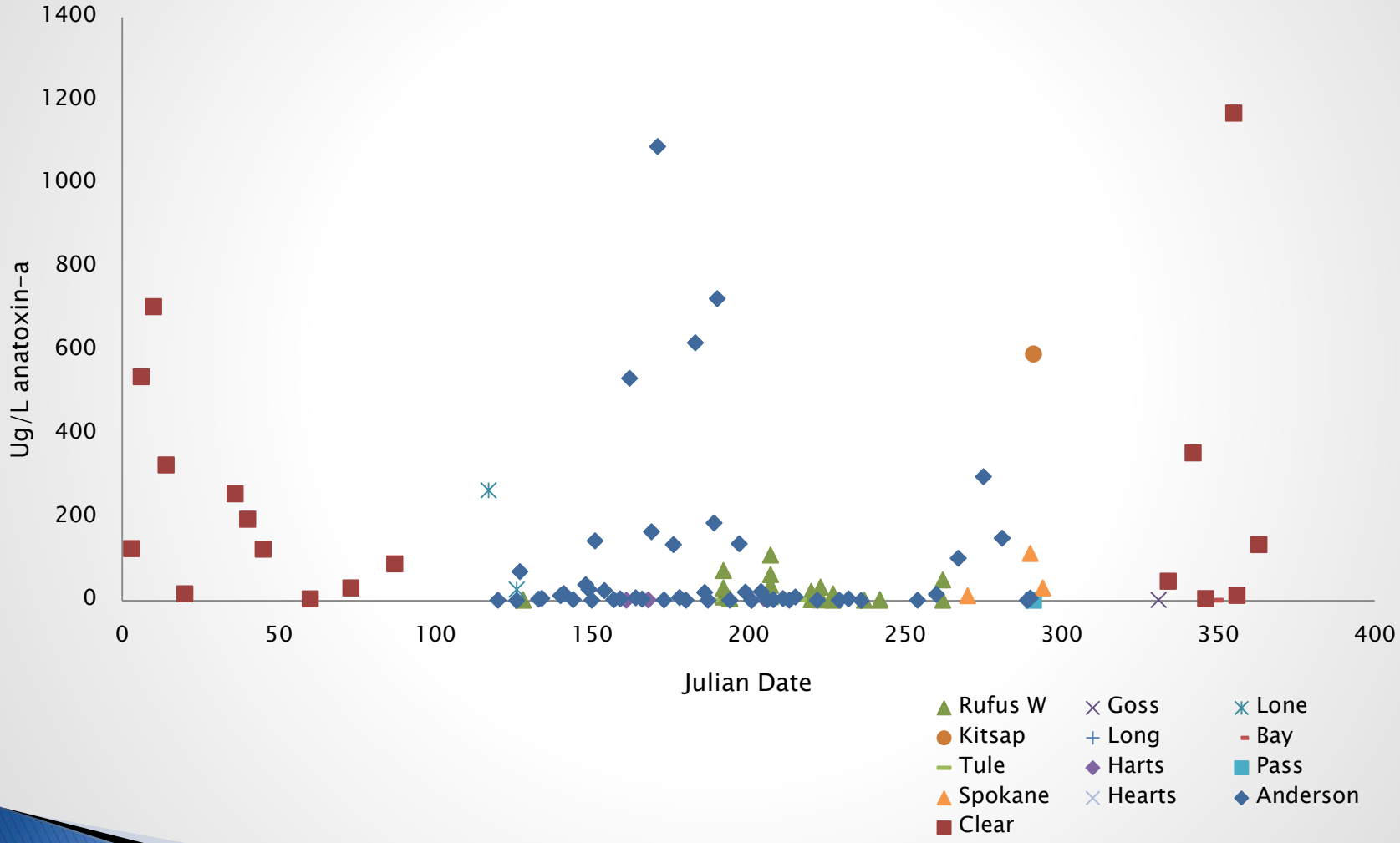
1	Spokane	Lake Spokane	10/17/2011	26400
2	Pierce	Waughop Lake	8/17/2011	25200
3	King	Green Lake	9/11/2014	25000
4	King	Green Lake	9/9/2014	23800
5	Spokane	Lake Spokane	9/23/2009	18700
6	Snohomish	Lake Cassidy	9/20/2011	18400
7	Spokane	Lake Spokane	10/5/2011	18400
8	King	Green Lake	9/12/2014	13753
9	King	Green Lake	11/12/2014	13500
10	Pierce	Silver Lake	9/22/2015	12300
11	King	Green Lake	9/12/2014	10513
12	Kitsap	Kitsap Lake	10/6/2009	8230
13	Pierce	Waughop Lake	8/4/2011	7080
14	Pierce	Bay Lake	10/5/2015	6410
15	King	Green Lake	10/22/2014	6298

Anatoxin-a

Year	# Lakes	# Samples above Std.	Maximum Conc. (µg/L)
2007	1	1	4,000*
2008	8	25	172,640*
2009	4	21	144,000*
2010	5	14	538
2011	8	32	1,170
2012	7	40	706
2013	6	25	257
2014	5	15	991
2015	9	27	7,951

*Original method

Anatoxin-a: Seasonal Distribution



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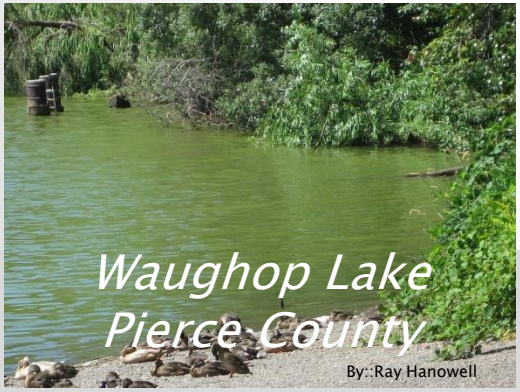
Saxitoxin and Cylindrospermopsin in WA Lakes

Saxitoxin Total N = 836	Cylindrospermopsin Total N = 914
1 sample > 75 µg/L	0 samples > 4.5 µg/L
6 samples < 75 µg/L and > 1 µg/L	4 samples < 4.5 µg/L and > MDL
65 samples < 1 µg/L and > MDL	910 samples < MDL
765 samples < MDL	
* 75 µg/L WA saxitoxin recreational GV	* 4.5 µg/L WA cylindro recreational GV



By: Gene Williams

"Dominant factors associated with microcystins in nine midlatitude, maritime lakes"

- Jacoby et al. 2015. Inland Waters 5(2): 187–202.
- 9 lakes sampled biweekly, 2012
- Identified factors most closely associated with 4 cyanotoxins
- Best predictors of MC:
  - When TN:TP ratios $\leq$ **25.7**
  - MC was generally absent when TN:TP ratios >25.7
- Poster

Washington State Department of Health

Clinic Posters

- Helps clients identify:
  - Toxic Blooms
  - Poisoning Signs
  - What to do if pet is sick
  - Who to call

Washington State Department of Health

Vet Reference Card

Blue-Green Algae Exposure and Clinical Information - There are no antidotes to these toxins. Medical care is supportive.

Exposure Route	Likely Signs	Onset to Signs	Differential Diagnosis	Possible Laboratory or Other Findings
Swallowing water with toxic blue-green algae (cyanobacteria) or other toxins **Licking fur or hair** contaminated with toxic blue-green algae	**Hepatotoxins** - Acute depression - Weakness & incoordination - Loss of appetite - Excess drooling - Vomiting and diarrhea - Abdominal tenderness - Jaundice - Dark urine	One or two hours, or more	Acetaminophen, nonsteroidal anti-inflammatories, aflatoxin, mushrooms, copper, zinc, iron, xylitol, sago palm	- Elevated bile acids & liver enzymes - Hypoglycemia - Prolonged clotting times - Proteinuria - Presence of toxin in clinical specimens (liver, gastrointestinal contents) collected from animals
	Neurotoxins - Excess drooling - Apprehension & anxiousness - Vomiting - Muscle twitching - Seizures - Respiratory failure	Minutes to hours	Organophosphate and carbamate insecticides, strychnine, metaldehyde, pyrethrins, moldy foods, chlorinated hydrocarbon pesticides, bromethalin, mushrooms	- Presence of toxin in clinical specimens from stomach contents taken from animals that became ill
Skin contact with toxic blue-green algae or other toxin(s)	**Dermal Toxins** - Rash, hives, allergic reaction	Minutes to hours	Other dermal allergens	- Blue-green staining of fur or hair

Monogastric animals appear less sensitive than ruminants or birds; however, the dose-response curve is very steep in dogs – up to 90% of a lethal dose may elicit no clinical signs. Surviving animals have a good chance for recovery. While therapies for cyanobacterial poisonings have not been investigated in detail, activated charcoal slurry is likely to be of benefit. Health effects from exposure are derived from reports of animal poisonings. For more information see Department of Health (www.doh.wa.gov/algae) or the Merck Veterinary Manual (www.vetmanual.com).

Veterinarian Reference Card

Algal poisoning is often an acute, fatal condition.

This card provides clinical information to help veterinarians identify blue-green algae (cyanobacteria) exposure and poisoning signs.

Fatalities and severe illness of livestock, pets, and wildlife occur among animals drinking or swimming in algal infested freshwater. Dogs may exhibit severe signs such as collapse and death within minutes to hours after swallowing contaminated water. Poisoning usually occurs during warm seasons but can occur year round.

There are no antidotes to these toxins.
Medical care is supportive. Activated charcoal may be useful within the first hour, and atropine has efficacy with saxitoxin exposure.

What are blue-green algae?
Blue-green algae (cyanobacteria) are literally blue-green bacteria that contain specific photosynthetic pigment. Three genera of cyanobacteria account for a majority of blooms: *Microcystis*, *Anabaena*, and *Aphanizomenon*. **A bloom can consist of one or a mixture of two or more genera and may contain liver and nervous system toxins.**

What is a toxic bloom?
When algae grow quickly, they may rise to the surface of the water and form a surface scum. If conditions are favorable for a bloom, a lake or pond can change from clear to turbid within a few days. As cells die, toxins are released into the water. Sometimes blue-green algae produce toxins that can affect the liver and central nervous system. Not all blooms are toxic and only laboratory tests can confirm whether a bloom is toxic or not. Since cyanobacterial toxins can be lethal to animals in relatively small amounts, caution should always be taken when a bloom occurs. Advise your clients "***When in doubt, stay out.***"

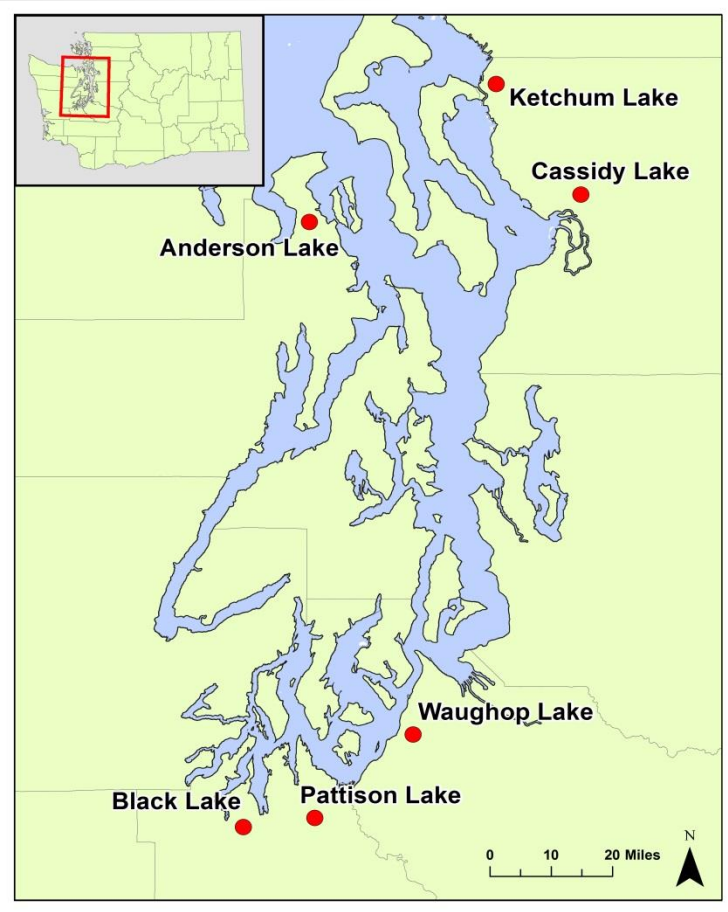
What causes a bloom?
No individual environmental condition causes blooms to be toxic. Factors such as light, temperature, percent oxygen saturation, nutrient availability and depletion, wind patterns, internal lake mixing, growth stage, and zooplankton predation may play a role in bloom formation.

To report an animal poisoning call the Washington Department of Health at 360-236-3330 or visit www.doh.wa.gov/algae

Washington State Department of Health
DOH 332-115 June 2012

Washington State Department of Health

ECY Collected 10 Fish Species



Washington State Department of Health

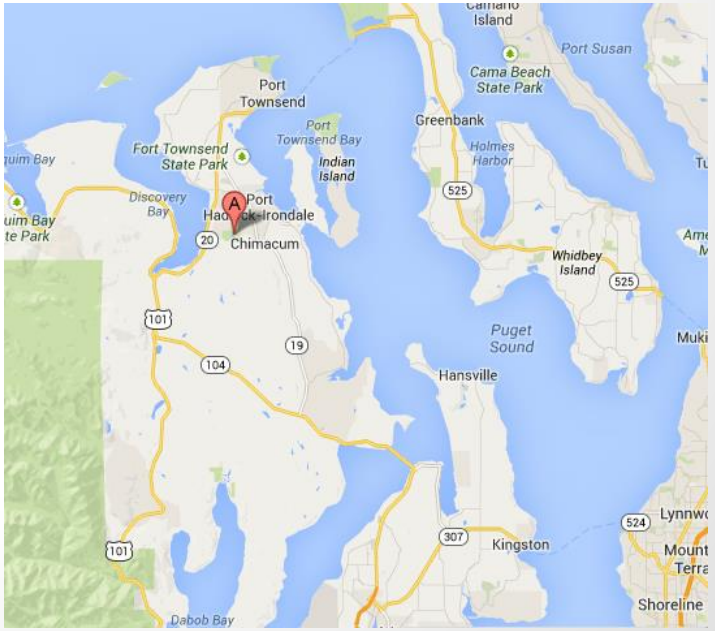
Confirmed MC in WA Fish

- Used two types of ELISA and LC-MS/MS
- Higher concentrations in the liver (X=50, 64 ug/Kg, wet) than in the gut or muscle tissue (X=5.6, 14 ug/Kg, wet)
- Recommend that ELISA be used only to screen fish tissue
- Recommend that LC-MS/MS be used in conjunction with ELISA to confirm results of screening

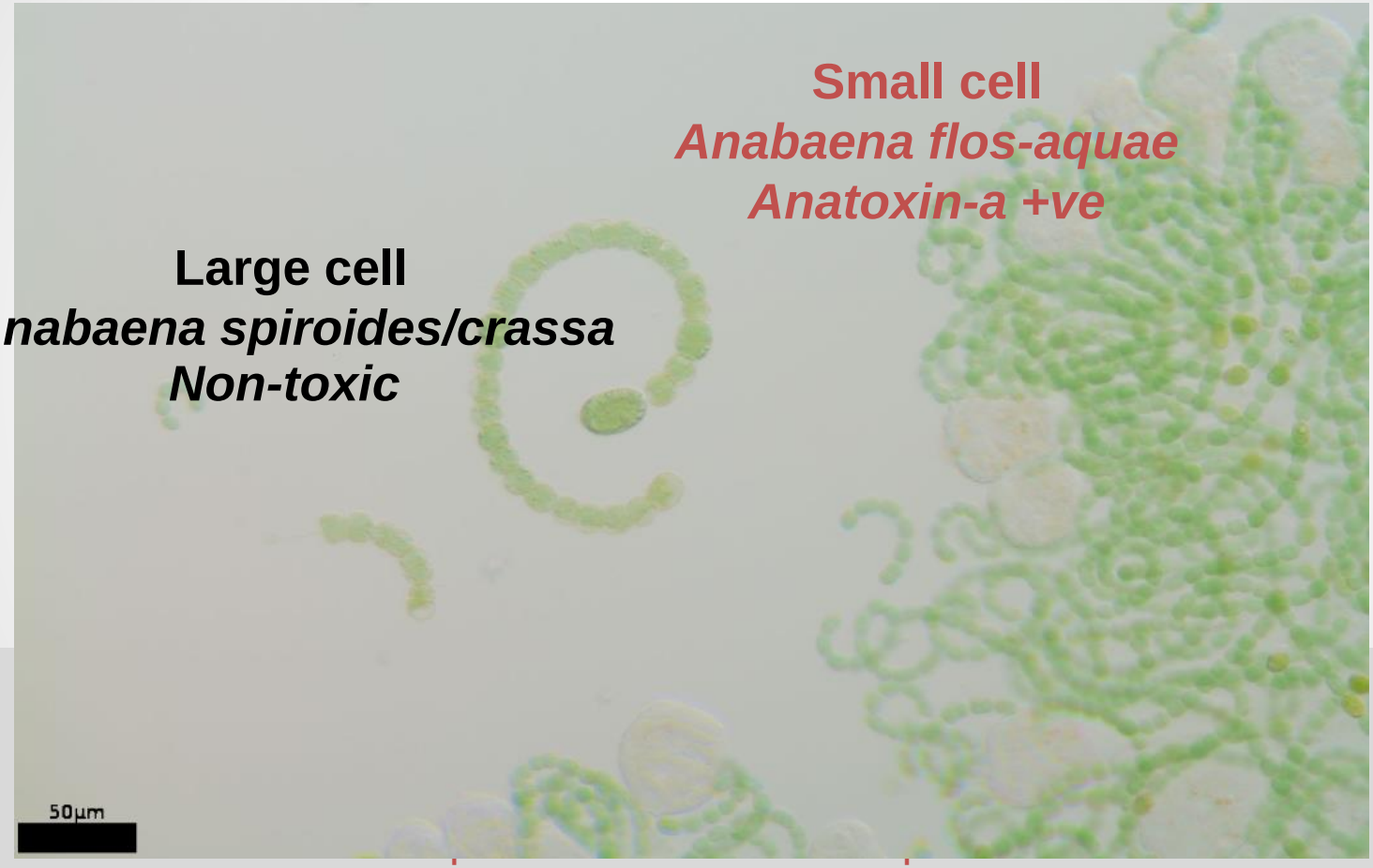
Hardy, FJ, A Johnson, K Hamel, E Preece. 2015. Cyanotoxin bioaccumulation in freshwater fish, Washington State, USA. Environ Monit Assess (2015) 187: 667

Toxic Gene Presence

- Puget Sound Lowland Lakes (2012 season)
- Anderson Lake, Jefferson County
  - Very high anatoxin-a concentrations



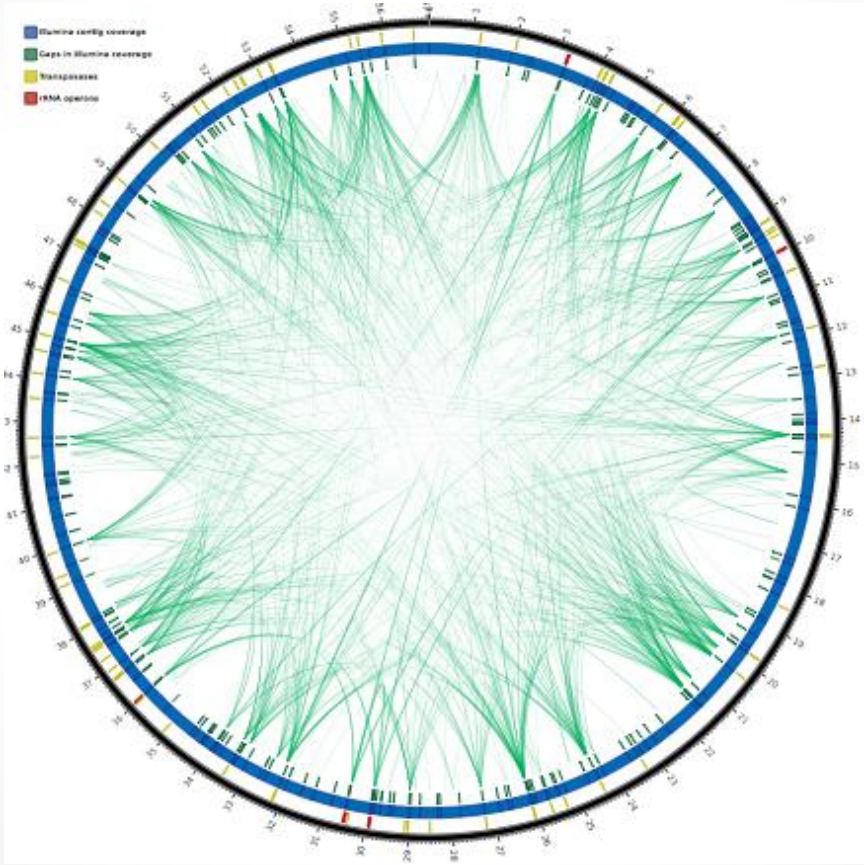
Anabaena flos-aquae-like morphotype is a major anatoxin-a producer in Anderson Lake



(9 July 2012 and 24 June 2013)

Oregon State OSU UNIVERSITY

Anabaena sp. WA102



Tested positive for anatoxin-a production

Culture from 5/20/2013

Washington State Department of Health

Oregon State University OSU

Mussels in Puget Sound

Pilot Project – 2012

- Bay Lake – Mayo Cove
- Lake Steilacoom – Chambers Creek
- Kitsap Lake – Chico Creek

Repeated in 2013, 2014

WSU analyzed MCs (E. Preece)

- Found MCs present in mussels associated with lake blooms

Washington State Department of Health

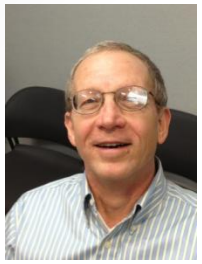
MC in Puget Sound Mussels

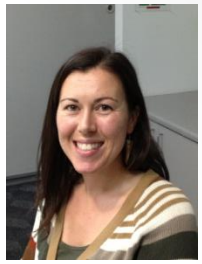
- Method development
  - Identifying best methods for routine ELISA detection of microcystin in seafood. 2015. Preece et al. Environ Monit Assess 187:12
- Detected MC in mussels
  - First detection of microcystin in Puget Sound, Washington, mussels (*Mytilus trossulus*). 2015. Preece et al. Lake and Reservoir Management, 31:1, 50-54.
- ID'd MC in lake, stream, and mussels
  - Transfer of Microcystin from Freshwater Lakes to Puget Sound, WA and Toxin Accumulation in Marine Mussels (*Mytilus trossulus*). Preece et al. Ecotoxicol Environ Saf 122-98-105.

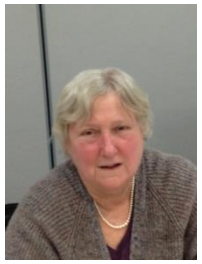
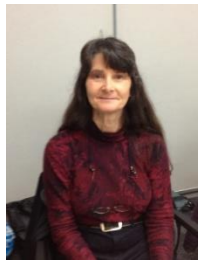
Future

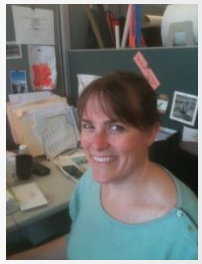
- EPA working on national recreational guidance values
- Animal illnesses can act as sentinels – vets
- FW/Marine interface
- Historic satellite imagery
- Biomarker work
- Sediments, periphyton
- Potential for increased HABs with climate change

Regional Examination of HABs Team







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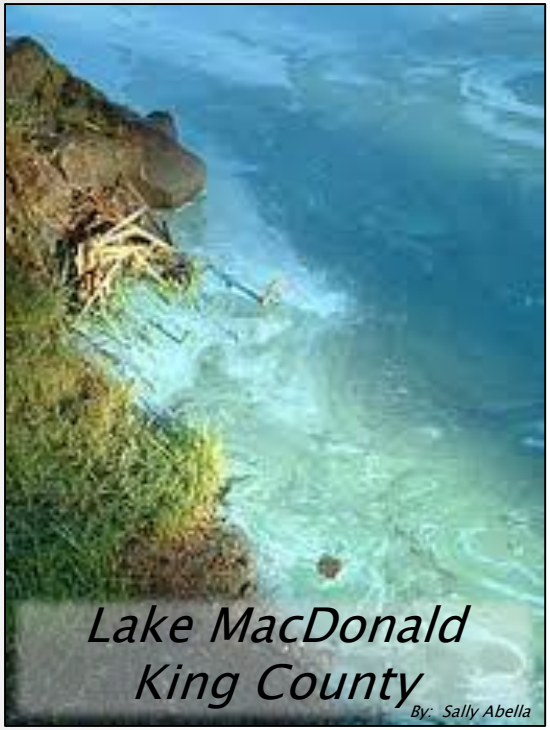

Questions?

Microcystins in Fish (ADDA ELISA)

Waterbody	Species	Tissue	N =	Microcystins (ug/Kg, wet)	Reference
Western Wash. lakes (5)	4 species	muscle	14	5.6	Present study
		liver	16	50	
Western Wash. lakes (6)	6 species	muscle	20	14	Johnson (2010)
		liver	11	64	
Lago de Patzcuero, Mexico	Carp	muscle	?	5.0	Berry et al. (2011)
		liver	?	94	
Lake Albufera, Spain	Mullet	muscle	103	5.0	Romo et al. (2012)
		liver	103	200	
Greek Lakes (13)	Carp	muscle	130	7.1	Papadimitriou et al. (2010)
		liver	130	124	
Lake Ontario and Lake Erie	17 species	muscle	57	7.8	Poste et al. (2011)